Application of Statistical and Actuarial Principles in General Insurance

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Introduction & Objective:

Life insurance business has always been based on actuarial principle from the beginning. The involvement of actuaries in General Insurance business is of recent origin. There are various reasons for this. Life Insurance policies are basically long term contracts and by their very nature are heavily reliant on actuarial / probability calculation and there was the recognition of this fact from the beginning. In contrast general insurance are short-term contracts and these were carried on more on adhocism rather than on sound actuarial principles. The rates could always be revised at next renewal if they proved inadequate. However, the actuarial principle and methods far assessing risk under conditions of uncertainty are as much applicable to general insurance as they are to life insurance. The services of actuaries are being utilized increasingly in general insurance also in areas like pricing, claims reserving, reinsurance placement, investment and in fact in most area of general insurance. The main reason for writing this article is to create an awareness about actuarial science amongst the practitioner of general insurance. In the days to come, more and more use of the actuarial techniques will be made in managing general insurance business and hence a proper appreciation and understanding of the same is required.

History and Background:

If we look back into history when insurance was in its infancy, we find that the judgment and skill of the underwriter in assessing the diverse risk and underwriting the same without statistical data was "key factor". But then the risk profile in those days was simple and the business was generally profitable and hence the need to base underwriting decision on past data was never felt and consequently the need to develop a system for collection of relevant statistical data also never arose. The fact of the matter is that insurance started without first evaluating the risk in the sense we understand it today. The insurer used to shoulder part of the risk for a price and it is only when the perils become a reality that damage assessment was made and shared according to an agreed basis. They were more in the assessment and apportionment of loss rather than in underwriting in the traditional sense. However, the 20th century (especially after World War-II) brought risk of previously unimaginable magnitude and complexity. Rapid development of new technologies brought new risk with insufficient experience. 20th Century also saw.

- High inflation, which meant that, claims settlement amount would be higher than claims cost provided in the premium.
- Fierce competition between insurer and hence rate-cutting
- Development of consumerism which meant changing of insurance companies for slightest of benefit

- Development of regulatory framework which meant more constraints for the insurance company and more compliance requirement

In view of these developments suddenly pricing and underwriting became very crucial for insurance companies to survive and remain in the business. This also meant greater focus on the solvency front. A need therefore was felt to develop ways and means to meet these challenges. Fortunately for us, 20th century also saw the development and growth of statistical theory and sophisticated computers with huge storage capacities that also enabled us to manipulate data and draw meaningful inferences which in turn can help in making more informed decisions**.** Actuarial principles basically make use of them and they provide us with necessary tools to manage modern day general insurance business with all its challenges and complexities. They are used for:

- Working out premium rates
- Provisions for outstanding claims
- Provisions for IBNR (incurred but not reported) & IBNER (incurred but not enough reported) claims.
- Prudential supervision (solvency concern, protection of policyholders interest, etc.)
- Retention limit / reinsurance plan
- Investment management
- Risk management

Statistical Tools:

Before we actually see how actuarial / statistical techniques are used for the above jobs, it is better to have a look at some of the relevant statistical tools that can help us in our task. As stated earlier, this article is meant for creating an interest in the subject only and hence the concept are discussed more in "passing reference" without going into much detail.

- Random variable and theory of probability
- Law of large numbers
- Various distribution models
- Measure of central tendency (average)
- Measure of dispersion or spread of data – range – deviation from central tendency
- Measure of symmetry by skew ness
- Measure of flatness or peaked ness by kurtosis
- Point and interval estimate of claims frequency (number of claims reported) and claim size (severity)
- Simulation techniques
- Interpolation & extrapolation

Let's try to understand these concepts in a layman's language. A variable is a measure that can assume any value within a given range of possible values. A variable is said to be a random variable if the chance of its assuming any value in a given range is equally likely. It is random in the sense that the outcome is uncertain and we do not know the

reasons why the variable assumes one out come in preference to the other options. A random variable can either be a discrete random variable or a continuous random variable. It is discrete if it is restricted to point values and cannot assume all values in any interval. On the other hand some variables, by their very nature are continuous and may assume any value over a continuous interval. For our purpose thus, the number of claims incurred by an insurance company is always a discrete random variable and the claim size on the other hand is always a continuous random variable. Random variables are amenable to statistical / mathematical treatment/manipulation to study their behaviour pattern and to make projections and hence the usefulness.

There is similarity between insurance and game of chance and therefore understanding the concept of probability and its application to general insurance is of importance to us. When we toss a coin, we say that the probability of getting a head is ½. There are two possibilities – head or tail – out of which one possibility i.e. head is favourable and therefore we say that probability of getting head is ½ or 50%. This is the theoretical way of calculating probability called "a priori" i.e. prior to experience. In contrast, we can not deduce theoretically the probability of a car being stolen within the year. For handling problems of this nature, we need to have data about the total number of cars and the proportion that is stolen. There is another way of looking at probability of getting head in tossing of coin which is more relevant for our purpose. If we go on tossing the coin and note the number of heads coming and if ideally this tossing is continued for infinite number of times we will find that the proportion of head coming is ½. Every time we are tossing, we are in effect generating experience. The fact that probability involves long run concept is important in the general insurance contract. Further head & tail are mutually exclusive events. The idea of mutual exclusivity can apply for example to calculating the probability of an injured employee being male or female, injured or killed, damages being above or below certain level, etc. We may say that if the event is certain to happen the probability is one and if the happening is absolute impossibility the probability is zero. If the probability of happening a claim is one i.e. a certainty no insurance company will assume such a risk except perhaps by charging the premium which is more than the sum insured. If the happening is an impossibility i.e. probability is zero, nobody would like to insure it. Between these two extremes, lies the various risk that come for insurance. The higher the probability of claims happening, the higher should be the premium. Probability thus attaches a numerical value to our measurement of the likelihood of an event occurring. We shall now examine the law of large number and the concept of probability distribution. We shall also see how these probability distribution help us in estimating the number of claims that will be reported in future during a given period of time and what will be the size of these claims. The law of large numbers in simple terms means that the larger the data, the more accurate will be the estimate made. In other words the larger the sample, the more accurate will be the estimates of the population parameters. In general insurance it would mean that the larger the past data about claims, the better will be the estimate of the prediction about claim frequency and size. It is assumed that the claim will occur in future as they have occurred in the past. What is a probability distribution? It is the listing of all possible values of a random variable along with their associated probabilities. For our purpose, the probability distribution can be considered to be a mathematical model which can describe the actual

probability distribution. Of course, the actual probability estimated from the available data will rarely coincide with those generated by the theoretical distribution. But the law of large number says that it will tend closer & closer if we have sufficiently large database. Even if the data available is not extensive, we can make use of various theoretical distributions to make meaningful inferences about the behaviour of data relating to a particular insurance portfolio. The fact that this theoretical distribution can be completely summarized by a small number of parameters is of great help. The shape of distribution is determined by its parameters. Parameters are numerical characteristics of population. If we have set of data relating to say claims size, we cannot make best use of them in their raw form. We may be interested to know about the average size of the claim. We have a whole set of measures called the measure of central tendency. Similarly to properly understand the significance of the data, it is essential to know the variability of data around the central tendency. In case the variance is too high, may be one has to decide about the required reinsurance support. Yet another aspect to properly understand the given set of data is the "Skew ness aspect". The distribution may be very symmetric or it may be skewed having long trail to the right (positively skewed). Many of the distribution we encounter in general insurance is skew with long tail to the right. We have a measure of this skew ness which is zero for symmetric distribution. Positive for positively skewed distribution and negative for negatively skewed distribution (long tail to the left). Again a knowledge and measure of flatness or peaked ness of a distribution is important for us. So we have what is called a measure of kurtosis. These aspects if known properly can help in better claims management. Fortunately for us, there are theoretical distribution models which approximate the existing claims data relating to various risk categories. The actuaries make use of these models. These provide methods of summarizing aspects of complexities. Some distributions are continuous in nature and may relate to claim size distribution and in the analysis of heterogeneity. The others relate to discrete variables and hence are helpful in studying the claim numbers distribution. Some of the important distribution model are:-

1) **Normal Distribution** – It is a continuous bell-shaped symmetrical distribution. It helps us to find the claim size. WE can find out the probability that a particular claims is between X & Y (X &Y are claim sizes). Whatever may be the distribution of claims size in respect of a particular class of business, the distribution of the total payout over a large number of years will approximately be normal distribution. This is what is called central limit theorem and its importance for us is very obvious.
2) **Binomial Distribution:** If a coin is tossed n times, the probability of getting x heads can be determined using this distribution. For our purpose whenever a policy is issued, having a claim in the policy can be likened to obtaining a head and not having claim to obtaining tail. It can thus help us to estimate the frequency of claims. When the risks are not homogenous we make use of negative binomial distribution for this purpose.
3) **Poisson Distribution:** This is a discrete distribution. It is generally employed for analyzing and estimating the incidence of claims. This is a non-negative integer based distribution. It is usually reasonably safe to assume that the number of claims on a policy in a given period follows the poisson

distribution. Unlike life insurance, general insurance policies are subject to multiple claims and hence more amenable to poisson distribution. It helps in finding out the chances of a certain number of claims being reported during a particular period.

4) **Log Normal Distribution:** This distribution model, which is continuous in nature, is a useful model for the claim size distribution as it is positively skewed and this is an important feature of claim size distribution. It has range from zero to infinity. The distribution tails are important for Reinsurance purpose and we must not under estimate it. If log normal distribution is appropriate, then we can calculate estimate of the tail probability. Classes of insurance in which claim tend to take a long time to settle are know as "long-tail" e.g. liability claims but this should not be confused with tail probability of log normal distribution.

5) **Pareto Distribution**: However, for Reinsurance purpose *pareto* distribution is more satisfactory than log normal. The pareto probability distribution function tapers away to zero much more slowly than long normal. Hence, it is more appropriate for estimating reinsurance premium in respect of very large claims.

6) **The Gamma Distribution:** This is also a continuous variable and finds application in the study of claims size distribution and analysis of heterogeneity.

In the light of what we have discussed above, we can say that if we have reliable extensive data with us, the observed distribution can be used to answer many questions. In practice this is not always the case however. Hence the alternative left is we formulate a model and make use of the theoretical distribution. But in a particular situation which model to use, is the domain of the actuary. A model can be used only when an adequate fit is obtained. For example, if the assumption made is "number of claims reported follow poisson distribution." Only one parameter defines this distribution and if we estimate the same on the basis of observed data, many of our questions can be answered e.g. What is the chance of getting more than 5 claims in a policy? In other distribution models, there may be more than one parameters. These parameters determine locations spread and shape of the distribution. The parameters of a distribution are unknown and we need to estimate them from the available statistics (data). If we are interested in estimating the claim frequency then perhaps we are more interested in a "point estimate." But for claim size it will more relevant if we can calculate the probability of claim size falling with a given limit rather than a specific point value. It is therefore useful to obtain an interval within which we are reasonably confident that the true values will lie. The next logical question would be "How much reliability can be placed in these estimate." Fortunately for us we have appropriate statistical tools for testing the reliability of these estimates as also how much confidence can be placed in them. These relate to what are called "statistical hypothesis testing and confidence limit." At this point it will not be out of place to mention here that in certain situations computer aided simulation can be a useful technique to solve difficult problems in general insurance. The simulation helps in imitating the uncertainty involved in the happening of events. We should also be aware of the sensitivity of the estimates to the various assumptions made and should update the

estimates as further data come to hand. If we have set of claim data over a period of time, then we can make estimate of the value on some intermediate time point through a technique called interpolation. If we want to make estimate at some future point of time, the techniques of extrapolation is used. Incidentally the various techniques discussed are also used by risk management department in organization for deciding risk retention.
Investigation of claims experience is very important in general insurance and we have seen the various theoretical distribution models and techniques that help us in the matter. The claim estimate helps us in

- Premium rating
- Reserving i.e. assessing the money requirement to cover cost of claim
- Reviewing reinsurance arrangement
- Testing for solvency i.e. assessing the company financial position (asset vs. liability)
- Effect of policy excess / excess of loss reinsurance / bonus and malus.

It is a fact that most of the people working in general insurance industry in Afro-Asian region do not have statistic / actuarial background. But it is also equally true that increasingly statistical / actuarial techniques are now being used as a tool to better price the general insurance products, to ensure adequate reserving and to make proper reinsurance arrangement as also in monitoring solvency. While it is agreed that it may not be possible for every one of us to become master in statistics/actuarial science, it is desirable that we understand the availability of these techniques and the uses to which these can be put to. A proper appreciation is called for in that we should understand the problems that we face in general insurance and that these can be attended through actuarial tools. This is necessary for a practicing general insurance man to better discharge his responsibilities. Let's us at least appreciate these tools and techniques and let us keep ourselves abreast with developments taking place in this field vis-à-vis general insurance. Our obsession for data and our inability to make proper use of them once they are in our hands will definitely reflect on our working. The effort and the expanses that go into collecting the data will simply go waste.

The Indian Scene:

Prior to 2000 (i.e. before passing of Insurance Regulatory Development Authority (IRDA) Act 2000) there was hardly any involvement of actuarial expertise in general insurance in India. However, the situation changed after passing of the IRDA Act that paved the way for entry of private players along side the government companies which were delinked from General Insurance Corporation of India. So long the general insurance was in nationalized set-up, the solvency concern, though taken care of in Insurance Act of 1938, were not being paid much attention. With the opening of insurance sector, the policyholders' interest and solvency concern suddenly became very important. The concept of appointed actuaries was introduced in the IRDA Act 2000. It became mandatory for the general insurance companies operating in India to have "Appointed Actuary" who has to certify:

- the reserves which is to be calculated on sound actuarial principles

- Valuation of assets, liabilities & solvency margins (maintenance of solvency margin at all times)

Basically the responsibilities of Appointed Actuary are centered on the protection of policyholders' interest. But he is also a watchdog of IRDA.

Establishing proper reserve is very important as both under reserving and over reserving have serious implication if continued over a period of time. It may result in insolvency of the company. In sixties and seventies a number of U.K. companies collapsed because they have not taken into account the fund requirement for future claims notifications. The regulators therefore in various countries have come out / have in place appropriate legislation / regulation to take care of appropriate reserving and its certification. The actuaries in general insurance are now being increasingly used in the area of product design and pricing, investment and reinsurance. As for their mandatory role in India, the Appointed Actuary is not only the watchdog of the policyholders but they have also to provide inputs to the sound management of the business. While in some countries, statutory role of actuary is limited to "Point-in-time" opinion, in India the requirement is to monitor the position on an ongoing basis and they are required to inform IRDA should there be any violation. The companies must be solvent at all times to meet their obligations.

Conclusion:

In summary, we can say that actuarial techniques provide powerful tools in the hands of general insurance practicener which can be of immense help in properly managing the affairs of the companies in more scientific and informed manner. This facts has been recognized by the regulators in most of the countries and actuarial certification of certain aspects of the working of general insurance companies are regulatory requirements.

Reference: 1. Introductory statistics with application in General Insurance
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